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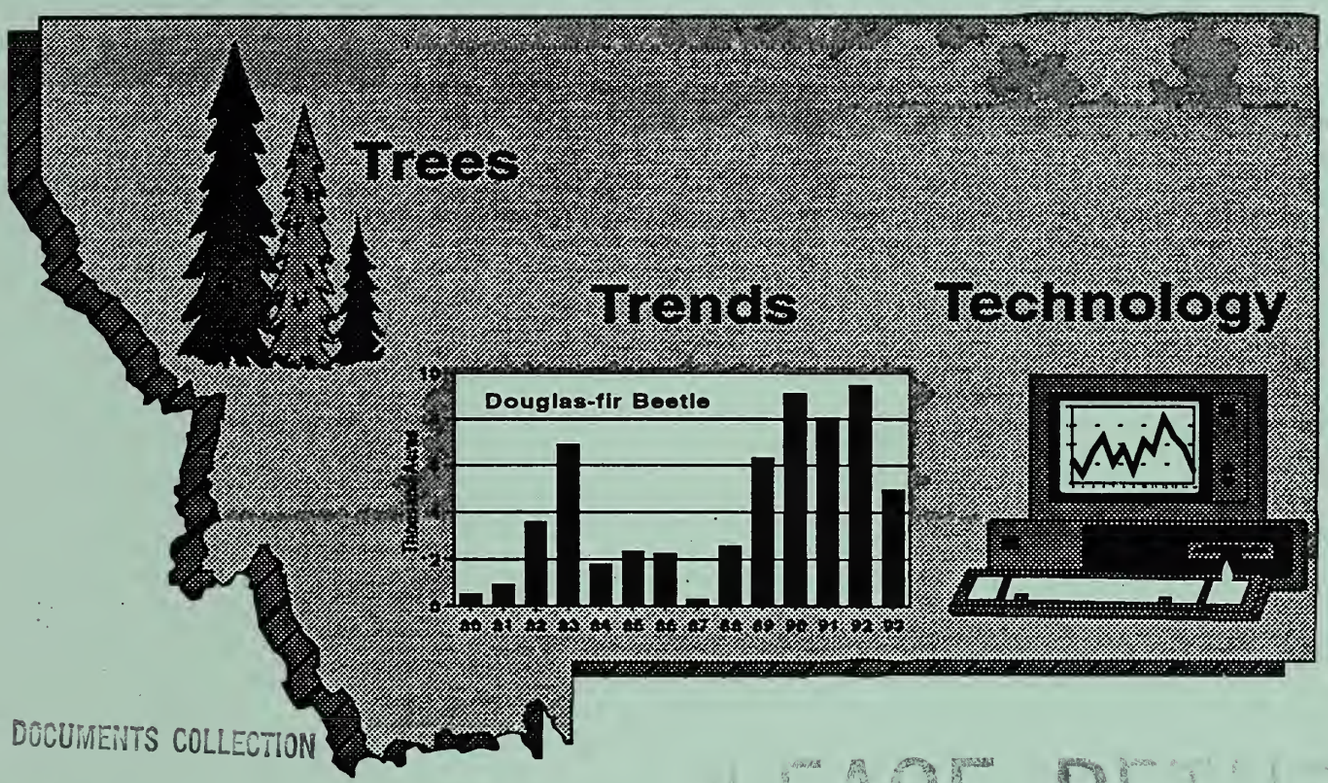
Forest Insect & Disease Conditions and Program Highlights 1993



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MONTANA INSECT & DISEASE CONDITIONS AND PROGRAM HIGHLIGHTS

1993

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Forestry Division

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INTRODUCTION

This report summarizes the major insect and disease conditions in Montana during 1993, and was jointly prepared by Timber, Cooperative Forestry, and Pest Management, USDA Forest Service, Northern Region, and the Montana Department of State Lands. Information for this report was derived from ground and aerial surveys conducted on forested lands throughout the State, except most national forest wilderness areas.

SUMMARY OF CONDITIONS

Principal agents causing the most damage to forest trees in Montana in 1993 were root diseases and mountain pine beetle.

Western spruce budworm-caused defoliation in 1993 decreased to the lowest level since records have been kept starting around 1950. A similar decrease in western spruce budworm defoliation was seen across the entire western United States.

The number of acres infested by mountain pine beetle continued to decline to the lowest levels since 1967. Infestations occurred in 1993 on 43,439 acres, again primarily in lodgepole pine. Montana, along with most western states, continues to see subalpine fire mortality at the higher elevations. Western balsam bark beetle contributed to much of this mortality, along with drought, stand age, root disease and fire suppression. Douglas-fir stands infested by Douglas-fir beetle were again lower than the previous year. Pine engraver in lodgepole pine has dropped significantly from the higher level after the 1988 fires in and around Yellowstone National Park.

Douglas-fir tussock moth pheromone trap catches were at their lowest levels since the trapping program started.

Incidence of root diseases remains high throughout the State, though most mortality occurs west of the Continental Divide. Past management practices, such as selective harvesting and fire suppression, have increased the proportion of root disease-susceptible species in a number of habitat types around the State.

Annosus root disease continues to be very damaging in ponderosa pine stands in western Montana, and has been especially prevalent in areas where trees have been selectively harvested. It has also been found causing mortality in Douglas-fir and may be the causal agent in the increasingly common subalpine fir mortality. Schweinitzii root and butt rot continues to be common on Douglas-fir throughout its range. Armillaria root disease also continues to be very damaging in many stands, especially those with large proportions of Douglas-fir and true firs.

Dwarf mistletoes still persist on about 2.5 million acres, resulting in an annual growth loss of approximately 33 million cubic feet. The species most affected by dwarf mistletoes in Montana are lodgepole pine, Douglas-fir, and western larch.

Diplodia blight continues to cause damage and mortality on ponderosa pine. Elytroderma needle cast has been chronic for the past few years in the Bitterroot Valley, the Flathead Indian Reservation (IR) and around Flathead Lake. Lodgepole pine needle cast was widespread again this year, but severe only in localized areas. Larch needle cast and needle blight were still present across the range of western larch.

White pine blister rust has persisted throughout the range of western white pine and whitebark pine, and has prevented the management of wild-type western white pine on moderate- to high-hazard sites. It also continues to cause extensive mortality in whitebark pine stands, as well as limiting the production of cones.

Damage and mortality from Dutch elm disease continues, although it may be declining with declining numbers of live elms. Beetle trapping done a few years ago by Montana Department of State Lands indicated the vector for Dutch elm disease is widespread throughout the State, so mortality from this disease is likely to continue.

FOREST HEALTH ASSESSMENT USING DISEASE AND INSECT REGIME CHARACTERIZATIONS

The spatial and temporal patterns of insect and pathogen activities influence and are influenced by forest vegetation patterns. Insect and pathogen activities which have significant outcomes will alter the course or timing of changes in vegetation. The patterns of these significant activities, whether it is the parasitism of dwarf mistletoe plants on lodgepole pine trees or the massive, localized killing of mature Douglas-fir by Douglas-fir beetles, are recognizable as "regimes." Like fire regimes, insect and pathogen regimes are associated with vegetation, physical features and climatic influences of a location.

A team of pathologists and entomologists is characterizing significant insect and pathogen regimes and describing associated functions for the Northern Region. Our objective is to provide a more comprehensive understanding of the current health of forests in this Region and the health trends forseeable in the next few decades.

The first step was to identify the major disease and insect regimes for broad geographic areas. After identifying a number of regimes, we characterized the vegetation or other relevant features which are associated with each type of regime. The current prevalence of each of these major regimes is assessed using samples of National Forests which had been selected for forest plan preparation. The probable prevalence of the regimes in forests prior to timber harvest or effective fire suppression is assessed based on historic vegetation conditions from circa 1935 surveys. The historic data were compiled largely by Jack Losensky. We did some further compilation from the archived data and maps to refine some of the white pine, western larch and ponderosa pine forest type estimates.

The freqencies with which particular disease or insect regimes associate with current forest conditions provides the basis for calculated frequency distributions of regimes in the circa 1935 forests (Figure X). Comparing the two distributions of regimes and applying our best understanding of the reasons for any significant changes will allow us to better understand forest health trends in this Region.

Combinations of insect and disease regimes into multiple disturbance agent regimes are being constructed on the basis of co-occurence of conditions associated with each of the single-agent regimes. For example, in a common regime on the Clearwater National Forest (NF), the combination of moderate root disease severity affecting primarily the Douglas-fir and grand fir components, mountain pine beetle killing much of the lodgepole pine in the area between 80 and 120 years of age, and severe white pine blister rust, with crown fires recurring at 150- to 200-year intervals on some grand fir habitat types results in a predictable pattern of vegetation change, nutrient recycling, habitat changes, and fiber productivity. Shortly after the stand-initiation phase, root disease and white pine blister rust mortality begins the rate at which the stands reach maturity on the average. Root disease will kill sub-mature Douglas-fir and grand fir, and blister rust will kill sub-mature western white pine, both providing conditions for increased grand fir regeneration and increased survival of lodgepole pine in the maturing canopy level. The retention of a large component of lodgepole pine provides good conditions for mountain pine beetle to reach sufficient population levels to kill much of the lodgepole pine in a series of peaks with a resultant release of sapling grand fir and a general shift to a younger age class overall. At this stage there is a fairly sparse overstory. Most of the surviving trees in the overstory will be grand fir or, if present, western larch. Both of these species are more resistant to root disease than is Douglas-fir. The developing grand fir understory also may develop significant amounts of decay where sufficient grand fir overstory remains to create the necessary conditions for infection by the Indian paint fungus. The canopy is generally patchy at this stage providing a variety of cover conditions within a stand.

This stage can self maintain with grand fir regeneration dominating patches created by continued root disease-caused mortality and overall growth approximately matching mortality in terms of basal area over large areas (a flattened wave pattern is produced in simulation models of this successional stage). The return of crown fire is expected to limit the time for this stage.

Each stage and event in this regime has characteristic composition, structure, canopy characteristics, and timber volumes associated. These more complete regimes will be reported for each broad geographic area, beginning with the historic "white pine region" which includes the Clearwater, Idaho Panhandle, and parts of Kootenai and Lolo NFs. The emphasis in this analysis is on the significant forest functions of pathogens and insects rather than population dynamics or impacts per se. We expect to provide information directly applicable to forest plan revisions from this first phase in our analysis. In the future, we expect to apply modeling techniques to this phase I characterization in order to increase our predictive capabilities and allow us to look more carefully at outcomes of various management alternatives.

THE ANNUAL AERIAL SURVEY

The summer of 1993 was one of the wettest and coldest on record. The average temperature in Missoula for September was warmer than July. The poor weather conditions for conducting the annual aerial detection survey pushed the final survey date to September 10. Most forested lands, except wilderness, were surveyed by Forest Pest Management personnel in 298 flight hours for the purpose of monitoring forest health in Montana. The effects of insect, disease and weather on forest landscapes were observed and sketch mapped from the air to provide most of the data summarized in this report. In 1993, 21,600,000 acres were surveyed from the air in Montana.

Areas not flown in 1993 include Rocky Boy's, Blackfeet and Fort Belknap IRs, the Rocky Mountain Division and portions of the Little Belt Mountains on the Lewis and Clark NF, upper Wise River drainage on the Beaverhead NF and all national forest wilderness. Additional areas flown included portions of Glacier National Park (NP) and the northern portion of Yellowstone NP, including all of the Montana portion of the Park.

INSECTS

BARK BEETLES

Mountain Pine Beetle

In 1993, mountain pine beetle-infested acres (all hosts, all ownerships) totalled just over 43,400, down from 66,100 acres in 1992. This is the lowest figure reported since 41,000 acres were recorded in 1966, and a mere 2 percent of the peak of almost 2.5 million acres infested in 1981.

Declines were noted in most locations and in most hosts infested. Exceptions were in ponderosa pine on the Flathead IR coming up from 1,200 acres (2,300 trees) to 7,200 acres (4,800 trees) in 1993; the Flathead, the Bitterroot and the Lolo NFs. Lodgepole pine stands saw a major decline in acres infested in western Montana, except for the Plains/Thompson Falls and Superior Ranger Districts (RDs) on the Lolo National Forest and the Swan Lake RD on the Flathead NF where serious outbreaks still continue. Total infested lodgepole pine acres dropped from 57,600 in 1992, to just over 29,300 in 1993. White pines stands continue to experience serious losses from a combination of blister rust, winter damage and mountain pine beetle. Some light and scattered sustained mortality was also noted in a few high-elevation whitebark pine stands.

In total, mountain pine beetle populations accounted for an estimated 112,000 trees killed in Montana (2.6 trees per acre). Though beetle popluations are currently low, much susceptible lodgepole pine remains in Montana. So long as suitable hosts are available, the threat of increasing mountain pine beetle depredation will exist. In the short term, a continued declining trend for the next few years is anticipated.

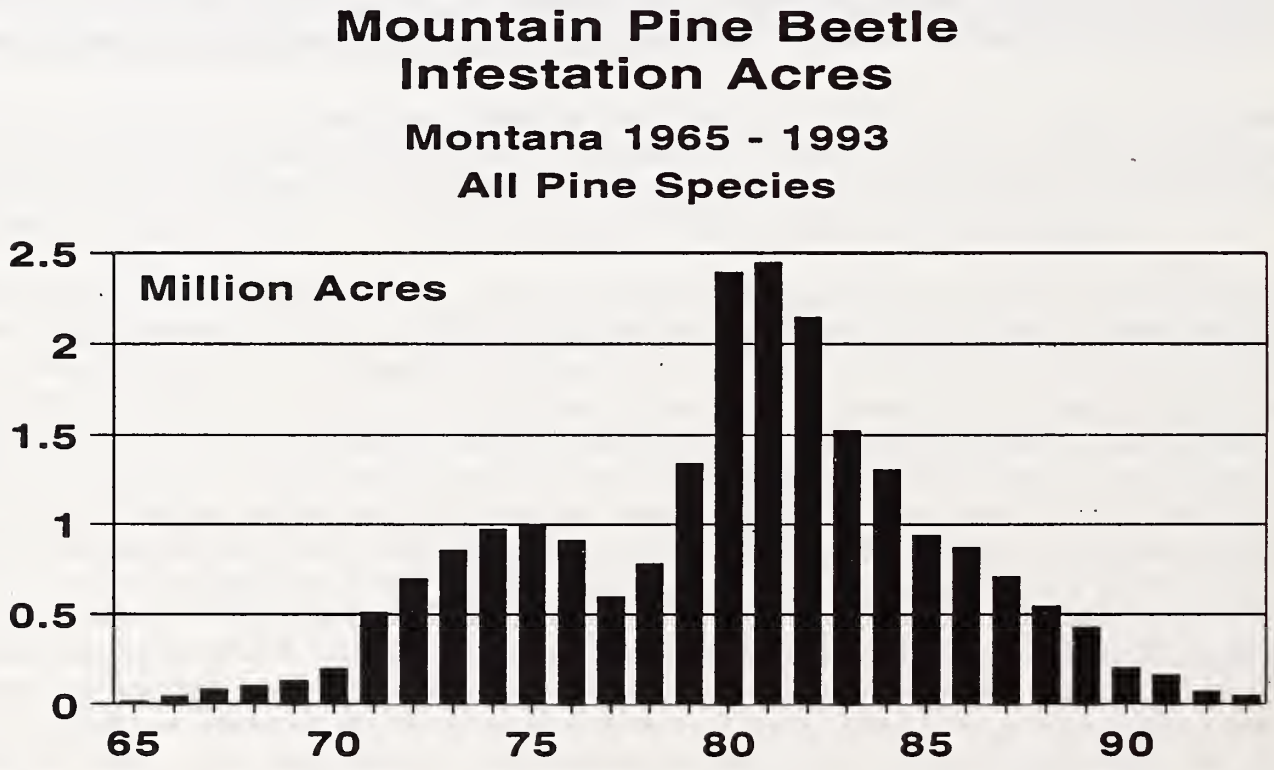


Figure 1

Table 1--Acres of mountain pine beetle-caused mortality on Federal and Indian Reservation lands in Montana from 1991 through 1993.

	1991				1992				1993			
Area	LPP[1]	PP	WBP	WWP	LPP	PP	WBP	WWP	LPP	PP	WBP	WWP
Beaverhead NF	489	-	-	-	2,041	6	138	-	201	2	42	0
Bitterroot NF	18	363	-	-	6	62	-	-	18	345	0	0
Custer NF	38	-	-	-	-	40	2	-	203	173	0	2
Deerlodge NF	960	2	-	-	168	-	-	-	52	12	0	0
Flathead NF	4,785	28	118	8,349	4,129	28	80	2,624	2,546	115	32	271
Gallatin NF	1,408	2	101	-	275	-	160	-	2,019	2	67	0
Helena NF	509	44	4	-	290	36	44	-	232	78	10	0
Kootenai NF	104,117	793	4	540	31,616	782	48	533	4,817	473	0	590
Lewis & Clark NF	-	42	-	-	212	153	149	-	431	78	0	0
Lolo NF	24,537	188	6	119	15,929	80	2	54	15,268	998	0	71
Total NF	**136,861**	**1,462**	**233**	**9,008**	**54,666**	**1,187**	**623**	**3,211**	**25,787**	**2,275**	**151**	**933**
Crow IR	-	44	-	-	*	*	*	*	4	80	-	-
Fort Belknap IR					76	129	-	-	*	*	*	*
Flathead IR	893	145	-	2	380	1,128	-	-	658	7,229	0	0
N. Cheyenne IR	-	40	-	-	*	*	*	*	0	56	0	-
Rocky Boy's IR	*	*	*	*	61	26	-	-	*	*	*	*
Total IR	**893**	**229**	**-**	**2**	**517**	**1,283**	**-**	**-**	**662**	**7,365**	**0**	**0**
BLM	141	14	2	13	299	20	54	4	135	56	6	0
Glacier NP									40	0	0	66
Yellowstone NP									2	0	0	0
Total (Non-FS)	**1,034**	**243**	**2**	**15**	**816**	**1,303**	**54**	**4**	**839**	**56**	**6**	**66**
Total	**137,895**	**1,705**	**235**	**9,023**	**55,482**	**2,490**	**677**	**3,215**	**26,626**	**2,331**	**157**	**699**

[1] LPP = Lodgepole pine; PP = ponderosa pine; WBP = whitebark pine; WWP = western white pine

* Not flown.

[2] NF = National Forest

[3] IR = Indian Reservation

Table 2--Acres of mountain pine beetle-caused mortality on State and private lands in Montana from 1991 through 1993.

	1991				1992				1993			
Area	LPP[1]	PP	WBP	WWP	LPP	PP	WBP	WWP	LPP	PP	WBP	WWP
Beaverhead NF	16	-	-	-	127	-	2	-	35	0	-	0
Bitterroot NF	2	1,051	-	-	2	68	-	-	8	306	-	0
Custer NF	2	-	2	-		2	18	-	4	19	-	0
Deerlodge NF	304	-	-	-	88	2	-	-	122	12	-	0
Flathead NF	301	106	-	114	121	94	-	60	190	504	0	573
Gallatin NF	111	-	-	-	-	2	26	-	485	10	4	0
Helena NF	38	53	-	-	84	78	4	-	100	186	2	0
Kootenai NF	3,184	146	-	12	540	64	-	20	75	70	-	60
Lewis & Clark NF	-	51	-	-	8	24	45	-	26	294	-	0
Lolo NF	3,089	278	-	-	749	170	2	-	253	548	-	2
Stillwater SF	461	30	-	988	48	2	10	261	6	0	-	358
Swan River SF	22	-	-	204	2	-	-	26	56	0	-	8
Thompson River SF	366	38	-	-	279	70	-	-	163	45	-	0
Garnets	24	233	-	-	18	132	-	-	40	0	-	0
Total	**7,920**	**1,986**	**2**	**1,318**	**2,066**	**708**	**107**	**393**	**2,726**	**1,994**	**6**	**1,001**

[1] LPP = Lodgepole pine; PP = ponderosa pine; WBP = whitebark pine; WWP = western white pine

Areas of mountain pine beetle infestations in Montana and Yellowstone National Park (all host species), 1993.

Douglas-fir Beetle

Douglas-fir stands infested by Douglas-fir beetle were much reduced in 1993. In Montana, beetle populations are present in Douglas-fir stands on the Gallatin and the Helena NFs. Even where beetles are still active, however, populations have declined from previous years due to sanitation/salvage efforts and a return to more normal precipitation. Total infested area declined from 9,400 acres in 1992 to 4,900 acres in 1993. An estimated 8,000 Douglas-firs were killed in Montana in 1993 (1.6 trees per acre), down from 12,800 trees in 1992. With a few exceptions, notably on the Lincoln RD, Helena NF and the Livingston RD, Gallatin NF, and barring major stand disturbances, the areas infested by the beetle should decline again in 1994.

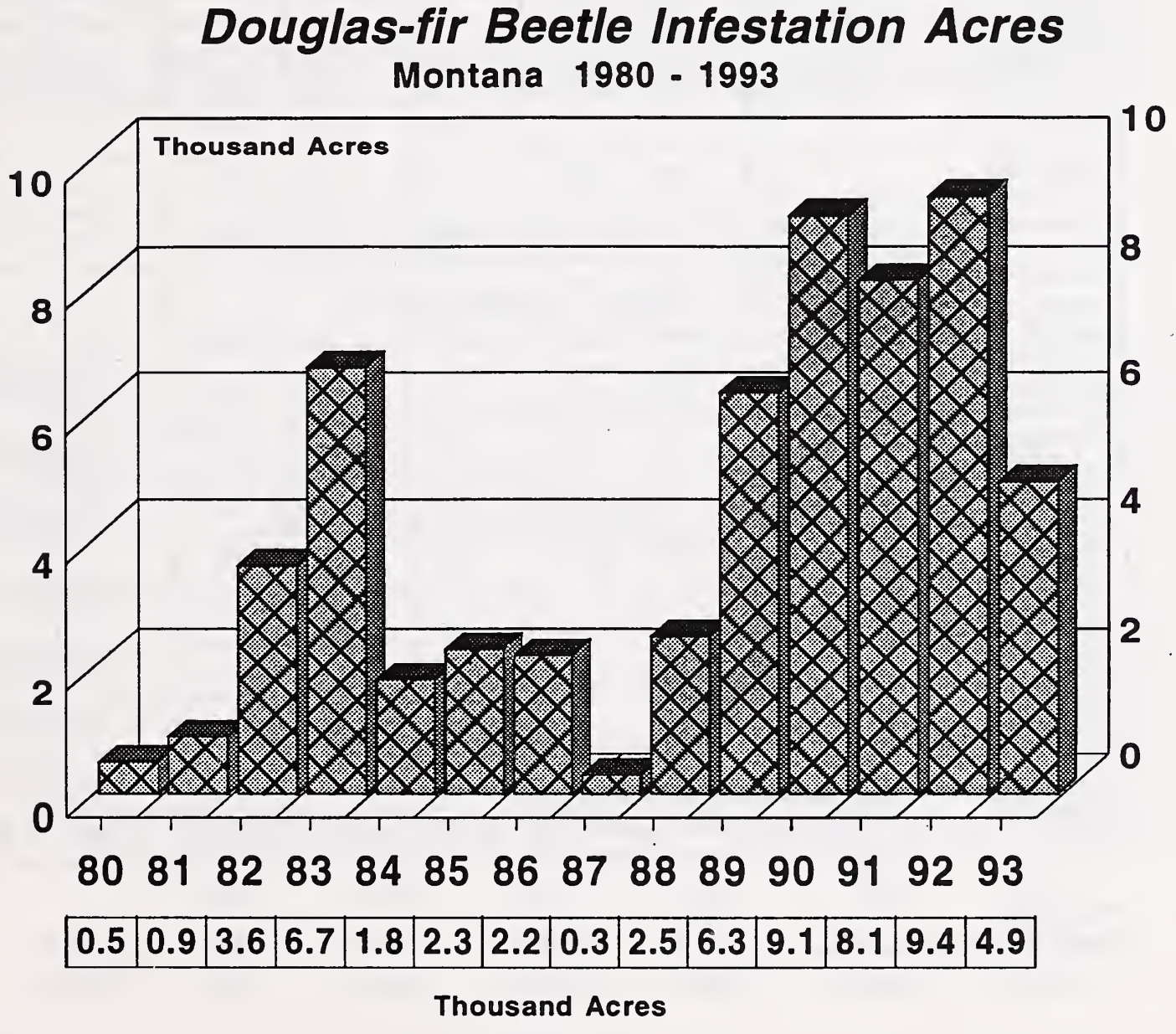


Figure 3

Table 3--Douglas-fir beetle-infested acres in Montana, all ownerships, from 1991 through 1993.

	1991			1992			1993		
Reporting Area	Acres	Trees	Vol. (MBF)[1]	Acres	Trees	Vol. (MBF)	Acres	Trees	Vol. (MBF)
Beaverhead NF	3,012	2,561	512.2	1,395	1,607	321.4	311	190	38.0
Bitterroot NF	2,769	2,920	876.0	1,770	2,947	884.1	201	467	140.1
Custer NF	4	9	1.8	2	20	4.0	562	711	45.2
Deerlodge NF	45	38	7.6	165	176	35.2	12	15	3.0
Flathead NF	194	302	90.6	770	774	232.2	510	907	272.1
Gallatin NF	*	*	*	1,183	1,210	242.0	1,034	1,182	871.0
Helena NF	12	18	3.6	35	114	22.8	503	1,104	220.8
Kootenai NF	1,240	991	297.3	472	616	184.8	589	1,155	346.5
Lewis & Clark NF	2	10	2.0	-	-	-	46	67	108.8
Lolo NF	1,546	1,446	433.8	1,775	2,475	742.5	606	1,051	315.3
Swan River SF	127	140	42.0	111	155	46.5	16	53	15.9
Thompson River SF	8	10	3.0	57	146	43.8	0	0	0
Flathead IR	117	225	67.5	80	153	45.9	156	295	88.5
Garnets	49	130	39.0	236	327	98.1	44	92	27.6
Crow IR							29	63	12.6
Glacier NP							214	483	144.9
Yellowstone NP							114	235	47.0
Other Areas							2	5	1.0
Total	**9,125**	**8,800**	**2,378.4**	**8,051**	**10,720**	**2,903.3**	**5,288**	**8,856**	**2,065.3**

* Not flown.

[1] (MBF) = 1,000 Board Feet

Western Balsam Bark Beetle

The beetle that is rapidly becoming the most prevalent in the State is the western balsam bark beetle. It has not, however, received the notoriety of the mountain pine beetle, nor has it had the economic impact. Because its host, primarily subalpine fir (rarely, grand fir), is not as important a timber species as are hosts of the mountain pine beetle, and also due to the high-elevation sites most often affected, this beetle may never be deemed as "important" as the mountain pine beetle. Its affect on infested stands, which may well be in association with other pests, has not been accurately assessed. Because of the critical role these stands have in watershed protection and as habitat for threatened and endangered species of wildlife, the importance of the beetle may be underestimated. There was a virtual static trend, 56,500 acres were infested in 1992, compared to 58,200 acres in 1993. The most expansive outbreaks continue to be found on the Beaverhead (22,600 acres) and Gallatin (34,600 acres) NFs. An estimated 36,000 subalpine fir trees were killed in 1993, similar to the 38,000 trees killed in 1992. To date, little is known about the beetle's life cycle and population dynamics. It is, therefore, difficult to predict a population trend. It is expected that since the beetle's activity is correlated with availability of susceptible host, populations likely will remain high so long as old, decadent subalpine fir stands remain. For the past few years, a similar mortality trend has been observed in subalpine fir across the western United States.

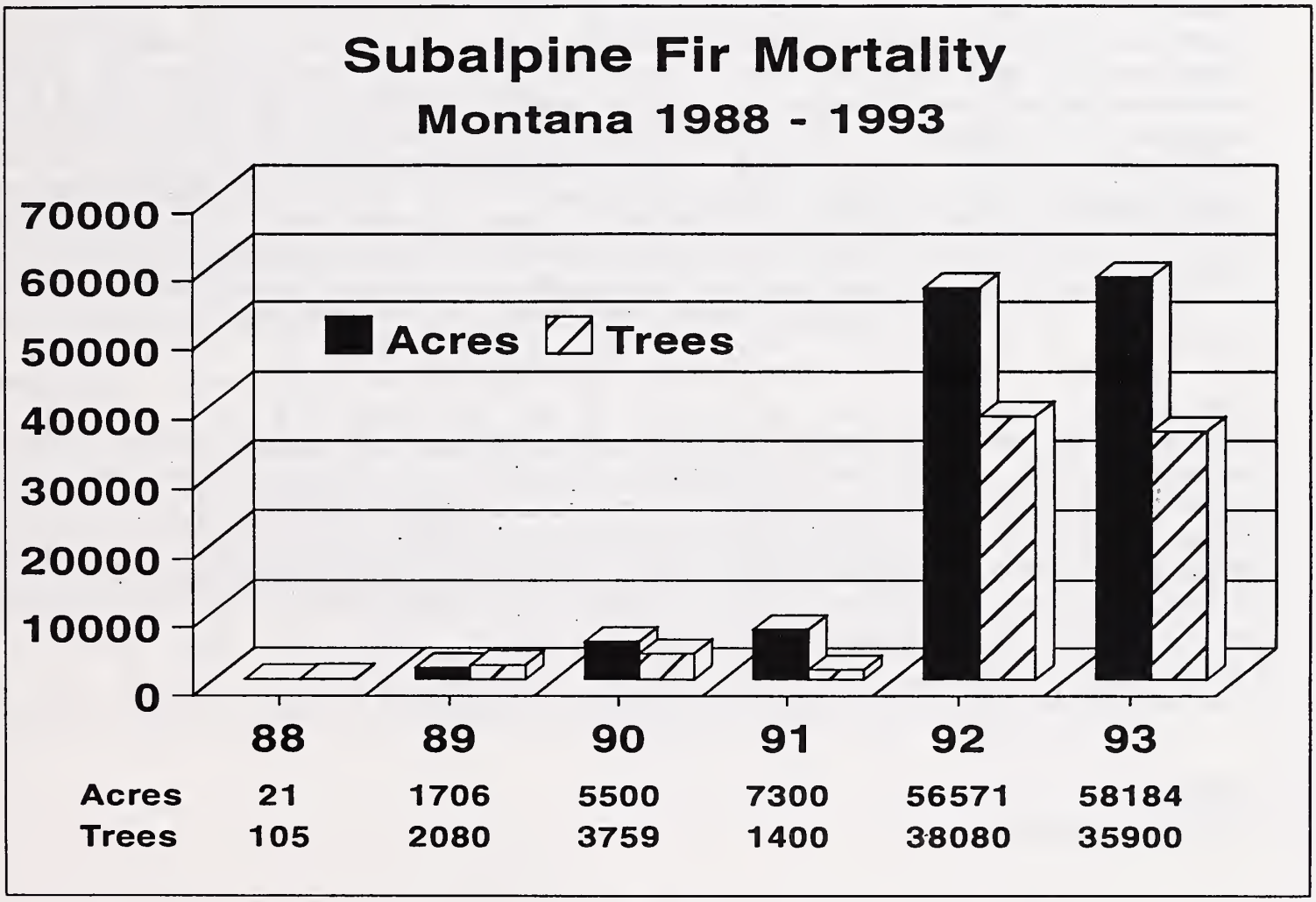


Figure 4

Table 4--Bark beetle-infested acres (other than mountain pine beetle and Douglas-fir beetle) in Montana, all ownerships, 1991-1993.

	Engelmann Spruce Beetle			Pine Engraver Beetle			Western Pine Beetle			Fir Engraver Beetle			Western Balsam Bark Beetle **		
Reporting Area	1991	1992	1993	1991	1992	1993	1991	1992	1993	1991	1992	1993	1991	1992	1993
Beaverhead NF	0	0	7	0	376	0	2	0	6	0	23	0	22,631	3,463	22,543
Bitterroot NF	4	0	0	0	16	0	180	90	144	0	6	0	36	53	10
Custer NF	2	0	0	663	39	2,169	0	0	0	0	0	0	161	6	70
Deerlodge NF	2	55	2	0	1,895	0	12	4	2	0	20	0	31	534	242
Flathead NF	34	35	20	4	0	0	164	16	42	54	90	20	137	341	173
Gallatin NF	245	0	0	5,951	2,943	27,936	0	0	12	0	0	24	34,610	1,998	32,454
Helena NF	22	2	29	2	0	0	48	114	126	0	0	0	92	200	254
Kootenai NF	33	15	4	2	2	0	250	20	2	58	12	26	36	48	38
Lewis & Clark NF	88	0	109	43	1,402	871	14	0	76	0	0	96	147	106	553
Lolo NF	12	*	*	4	0	0	384	98	0	57	182	0	*	479	174
Garnets	0	0	0	0	0	0	46	26	50	0	0	0	6	12	27
Flathead IR	0	2	0	20	127	2	164	222	88	12	149	22	12	61	24
N. Cheyenne IR	0	0	*	379	1,295	*	0	0	*	0	0	*	0	0	*
Stillwater SF	*	*	0	0	0	0	0	0	0	*	6	0	2	0	10
Swan River SF	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0
Thompson R. SF	0	0	2	0	0	6	12	16	0	2	34	0	0	2	22

* Not flown

** Mortality in subalpine fir

Western Pine Beetle

In western Montana, (western pine beetle has never been confirmed in eastern Montana), infested acres of ponderosa pine stands were estimated to have increased from 856 acres (600 trees) last year, to nearly 1,200 acres (680 trees) in 1993. Fewer trees per acre were killed in 1993. Western pine beetle is more weather dependent than most other bark beetle species. As such, population fluctuations are almost solely determined by precipitation and resultant condition of host trees. There has been a major increase in mortality of ponderosa pine due to western pine beetle across the greater Pacific Northwest over the past 4 years, especially in the smaller diameter size classes.

Fir Engraver

A pest almost exclusively of grand fir, the fir engraver is another primary tree killer. Like the western pine beetle, it is very dependent upon host condition. Its population also increases during periods of dry weather, but it is also associated with root disease-affected grand fir stands. As such, populations of fir engraver are maintained in many stands in a "high" endemic condition because of the prevalence of root diseases. Not frequently found in Montana, it is still common in weakened grand fir stands. Recorded only on 187 acres (190 trees) in 1993, almost all on the Lolo, Flathead, and Kootenai NFs, it is somewhat less than the 235 acres recorded in 1992.

Pine Engraver

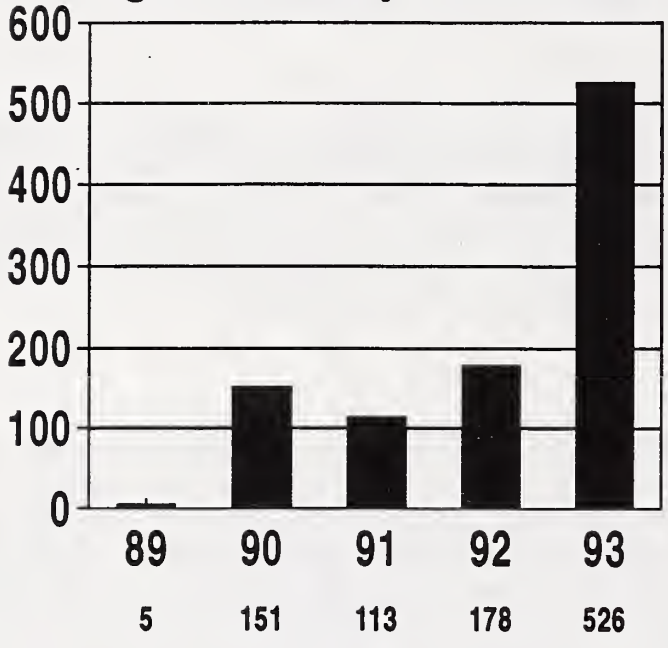
Like the fir engraver, pine engraver beetles are more of a secondary tree killers, where populations fluctuate with the degree of stress in the host. They, however, are attracted to slash or other downed host material, and populations often build to epidemic conditions following the creation and mismanagement of slash. Though most often a problem in ponderosa pine, outbreaks in lodgepole pine are not uncommon following some type of stand disturbance. Serious outbreaks, and subsequent killing of standing green trees, occurred in and around Yellowstone National Park following the fires of 1988. Those populations are finally declining, primarily in response to host depletion and improved moisture conditions. Where more than 27,000 acres had been infested on the Gallatin NF in 1992, only 5,900 acres were recorded in 1993. Infested acres in Montana totaled 7,000--almost all on the Gallatin and Custer NFs. Less than one tree per acre was estimated to have been killed. Populations in ponderosa pine stands are essentially endemic; only 50 acres were infested in 1993 in Montana.

Spruce Beetle

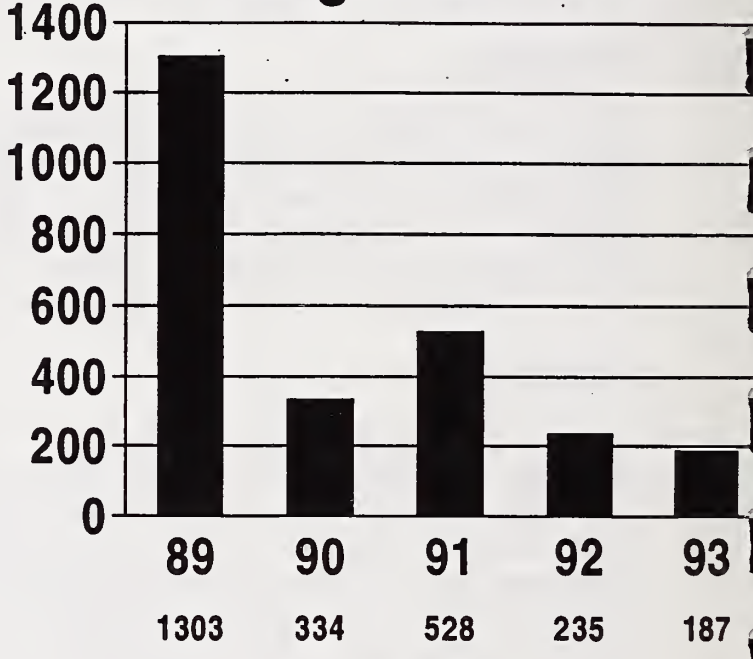
Except for an ongoing outbreak on the Gallatin NF near Cooke City, spruce beetle populations are low throughout Montana. This epidemic developed from fire-weakened trees in and near Yellowstone NP, and is continuing in large-diameter, older spruce in the area. Currently existing on approximately 300 acres, it is still threatening a large number of trees on National Forest and neighboring private land. Elsewhere in Montana, spruce mortality attributed to spruce beetle was confined to small, 2- to 3-tree groups in several high-elevation sites. In 1992, only 178 acres (133 trees) of spruce beetle-caused mortality were recorded, whereas 526 acres (362 trees) were recorded in 1993.

Other Bark Beetle Infestation Acres
All Ownerships
1989 - 1993

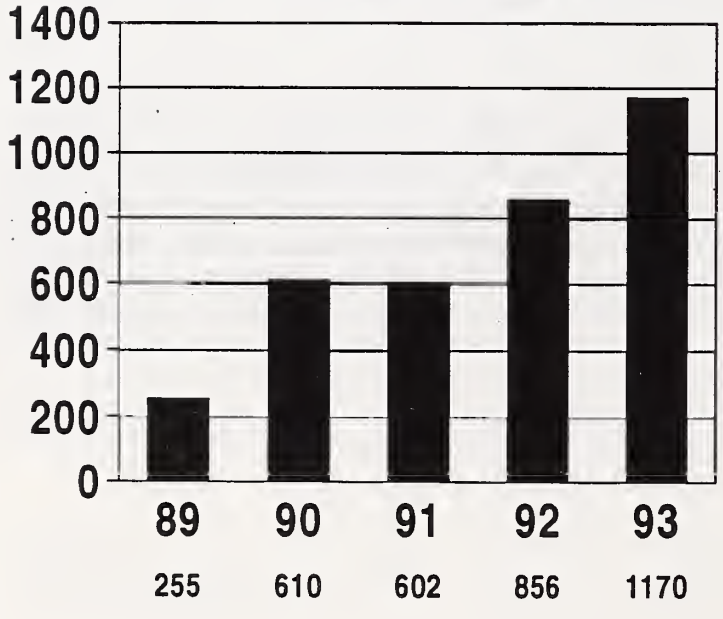
Engelmann Spruce Beetle



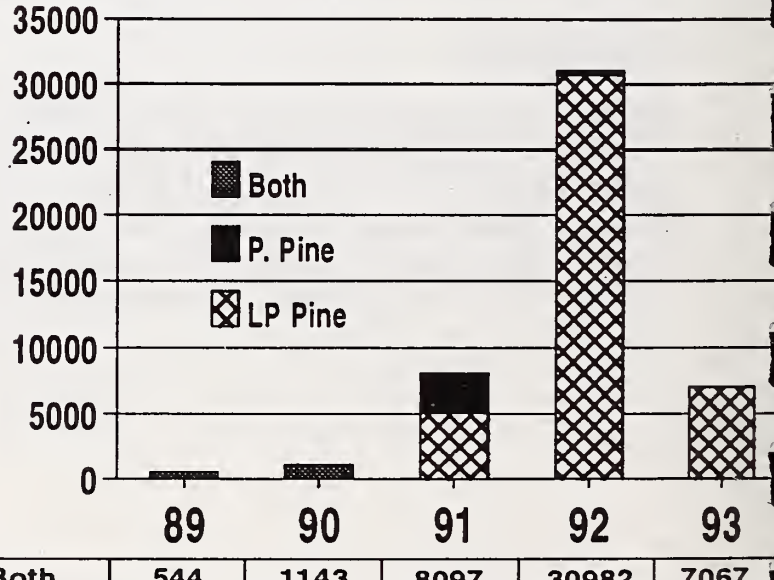
Fir Engraver Beetle



Western Pine Beetle



Pine Engraver Beetle (Ips)



Both	544	1143	8097	30982	7067
P. Pine	*	*	3039	315	52
LP Pine	*	*	5058	30667	7015

* Data not separated

Figure 5

Bark Beetle Technology Development Projects

During 1993, we conducted three projects in which we attempted to evaluate the effectiveness of pheromones to manipulate beetle populations to our advantage. In all three, we were evaluating the effect of anti-aggregating pheromones in protecting uninfested green trees or slash. The following is a synopsis of the projects.

Verbenone and Ipsenol as Anti-Aggregants of Pine Engraver. In this test, conducted in ponderosa pine stands on private land, northeast of Missoula, we were evaluating the effectiveness of aggregating pheromones of competitor beetles as anti-aggregants of the pine engraver. Applied in bubble-capsule formulations, one each of verbenone and ipsenol, we treated freshly created slash piles with four treatments of paired capsules. Four piles received no capules, four received five pairs, four received 10 pairs, and four received 15 pairs. Slash piles were created and treated in April. Evaluation was completed in June. Beetle flights were somewhat atypical this year, still, some treatment effect was noticed. Because treatment effect was not as pronounced as we had hoped, we plan to repeat the test in 1994.

Aerial Application of MCH to Protect Standing Green Douglas-fir. MCH, the anti-aggregating pheromone of Douglas-fir beetle, has proven effective in preventing beetle attacks in windthrown Douglas-fir. We had hoped to evaluate its effectiveness in protecting standing, uninfested Douglas-fir that were threatened by nearby beetle populations. Conducted on the Kootenai NF, north of Libby, we treated 17, 10-acre blocks in April. Four treatments were evaluated--no treatment, 10 grams MCH per acre, 30 grams MCH per acre, and 100 grams MCH per acre. The 30-gram treatment was equivalent to the "standard" treatment of 4 pounds of polymer beads--containing 2 percent MCH--per acre. Treatment evaluation was conducted in September. Unfortunately, there were not sufficient beetle attacks in any of the blocks to assess treament effect. We believe the abnormally cool and wet summer sufficiently disrupted, or prolonged, beetle flight in that area that populations were significantly reduced.

Aerial Application of Verbenone to Protect Uninfested Lodgepole Pine. Verbenone has been shown to be one of the important anti-aggregants of mountain pine beetle. It has been tested, with mixed results, as a means of protecting lodgepole pine stands from beetle attack until silvicultural manipulations could be used to reduce the stand's susceptibility. The test conducted in 1993 on the Superior and Plains/Thompson Falls RDs, Lolo NF, was an effort to reproduce one of our more successful tests which was conducted in 1988 in northwest Montana. We aerially applied 4 pounds per acre of verbenone-impregnated polymer beads to six, 20-acre blocks. Five additional blocks served as checks. Bead application was made twice--once before beetle flight in June, and the second during flight in August. Project evaluation was conducted in September. Though beetle flight was late, and less than anticipated, there were sufficient new attacks in all blocks to indicate there was little treatment effect. We do not consider these results an indictment against verbenone. Rather, we believe further testing of beads and their elution rates is needed before retesting this promising protectant strategy.

DEFOLIATORS

Western Spruce Budworm

Current Status

Western spruce budworm caused defoliation to Douglas-fir and true fir in Montana dropped to its lowest level since record keeping began in 1948 in the Northern Region. Spring and summer weather patterns throughout most of the Region were cool and wet for an extended period during 1993. As a result, budworm populations throughout the Region sharply declined. The wet and cool weather pattern adversely affected larval dispersal and development time. Aerial detection surveys conducted during 1993 in Montana recorded only 44,280 acres of visible defoliation compared with over 941,320 acres in 1992.

The greatest reduction in numbers of acres defoliated in 1993 was on the Helena NF. Aerially detected defoliated acres dropped from 168,160 in 1992, to 9,050 in 1993. The least affected was the Gallatin NF with only a 9 percent reduction in defoliation over last year.

Outlook for 1994

Budworm populations throughout the Region are not expected to fully recover very soon. Visible defoliation should remain very low during 1994.

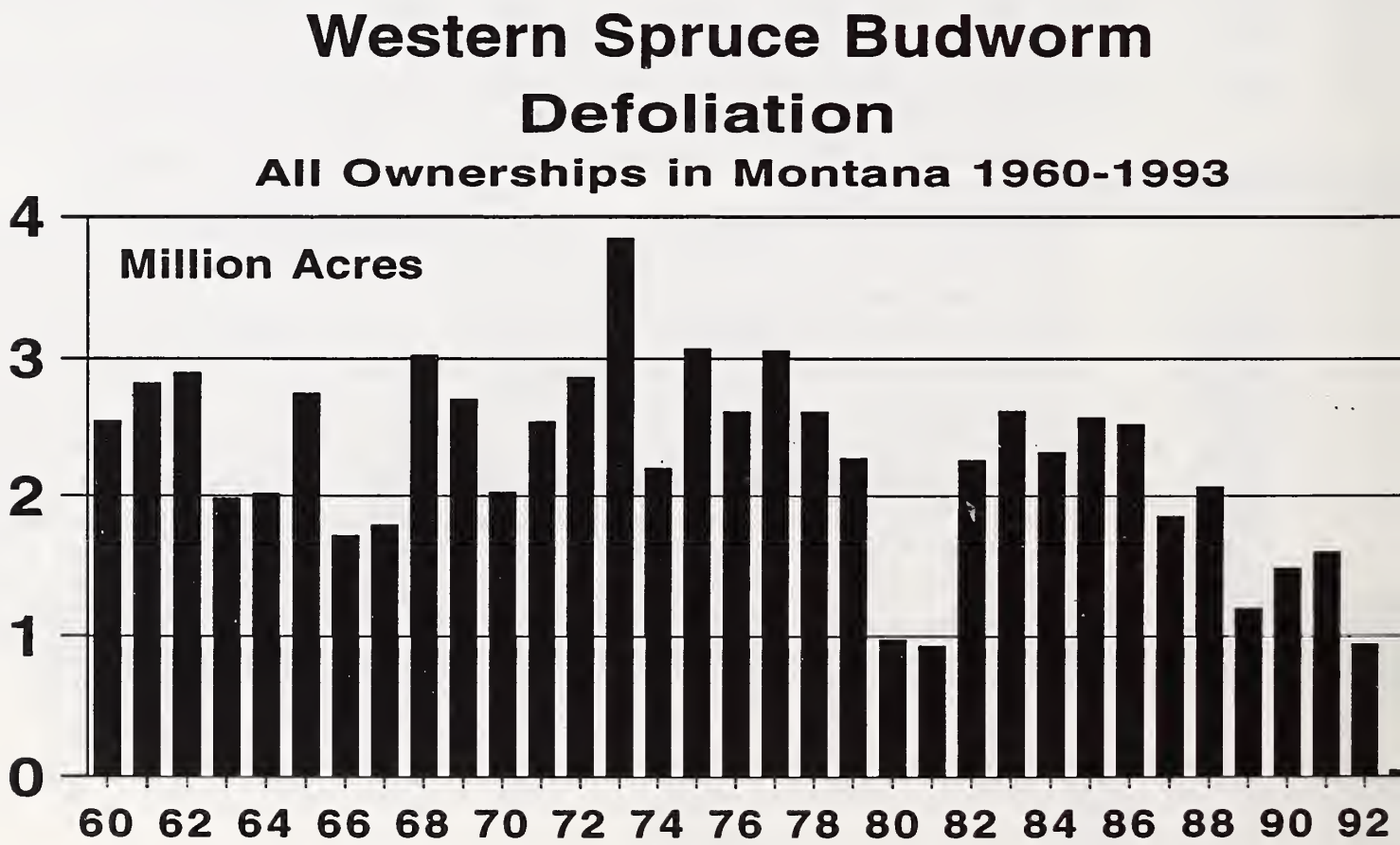


Figure 6

Long-Term Outlook

Although budworm populations are somewhat cyclic, in recent decades the classic rise and fall of populations is not as clearly defined. This is probably due in part to changing forest conditions resulting from selective harvesting of pines in the past, the large fires of the late 1800's, fire suppression after 1900, and the encroachment of host trees on marginal, more stressed sites. The resultant higher densities and proportions of host trees, has led to more extensive, severe and chronic outbreaks of budworm across the Region.

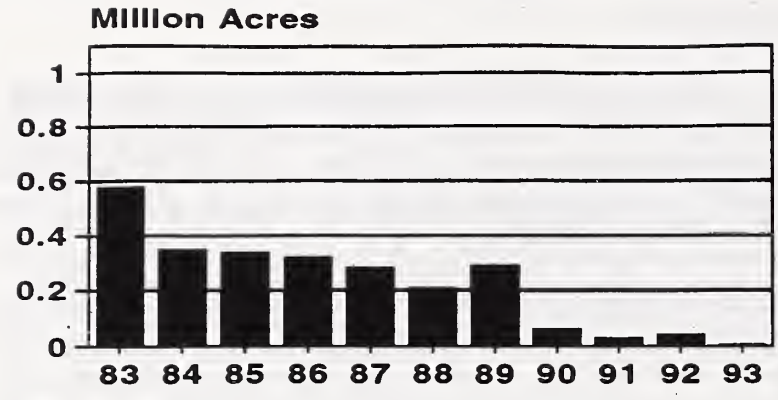
After several years, the budworm population probably will recover and continue to impact large areas, as we have seen over the past few decades. This trend will continue unless stand conditions are changed. In order for stands/landscapes to become more resistant to damage from budworm, we should strive to accomplish one or more of the following through management: (1) a reduction in continuous acreage of host type through either increasing the diversity of species or age classes across the landscape, (2) avoiding multi-storied conditions in chronic budworm areas, (3) increasing the number of openings to encourage predation, and (4) improving stand vigor.

Table 5--Acres of western spruce budworm defoliation visible from the air in Montana, 1991 through 1993.

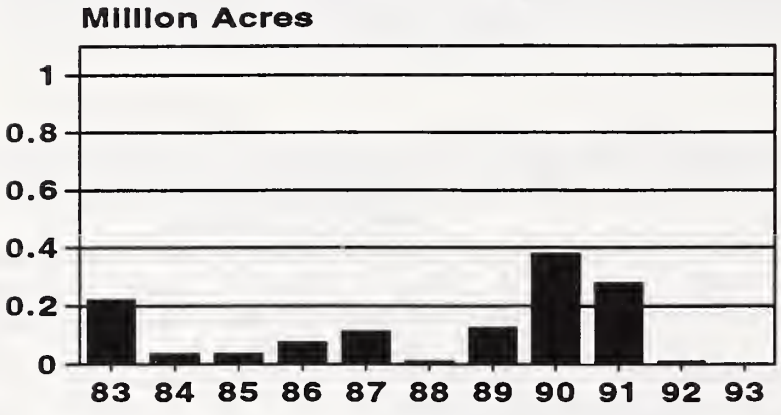
	All Ownerships			1993 Acres by Ownership				
Reporting Area	1991	1992	1993	IR	NFS	BLM	State	Private
Beaverhead NF	26,725	39,914	1,734	0	364	406	238	726
Bitterroot NF	276,085	8,560	1,091	0	631	0	240	459
Custer NF	8,782	0	0	0	0	0	0	0
Deerlodge NF	356,065	282,067	8,349	0	835	5,844	0	1,670
Flathead IR	55	67	0	0	—	—	—	—
Gallatin NF	30,932	6,321	5,810	0	1,384	0	0	4,426
Garnets	165,828	14,514	1,163	0	0	73	44	1,046
Helena NF	331,489	415,182	22,356	0	12,1409	493	277	9,445
Lewis & Clark NF	210,039	145,826	1,217	0	333	111	112	662
Lolo NF	189,569	28,869	2,558	0	2,007	5	79	466
TOTAL	**1,595,724**	**941,320**	**44,279**	**0**	**17,694**	**6,932**	**750**	**18,900**

Western Spruce Budworm Defoliation Acres 1983 - 1993 All Ownerships

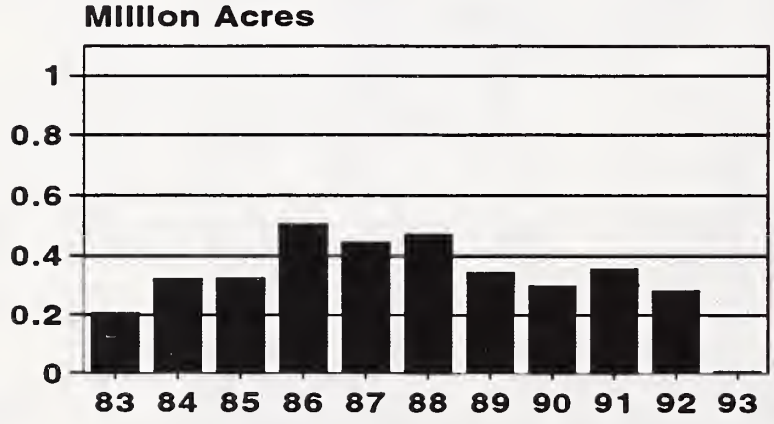
Beaverhead



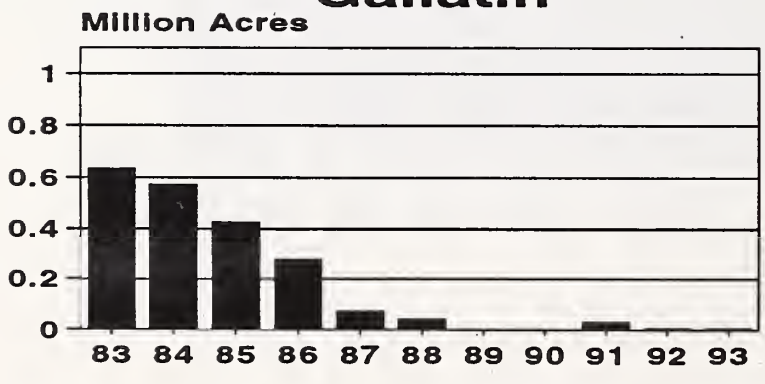
Bitterroot



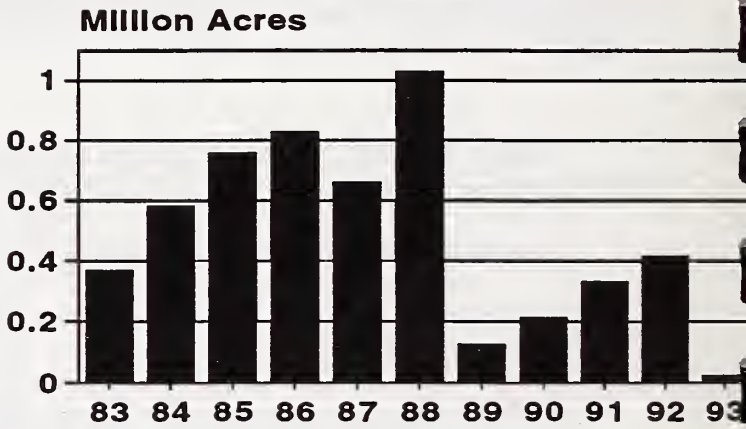
Deerlodge



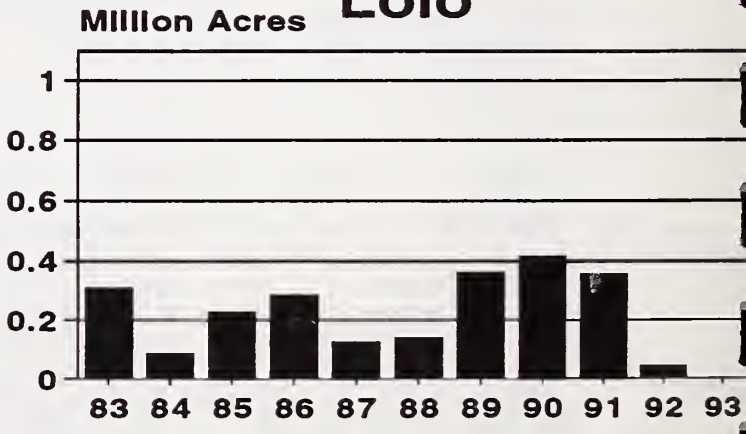
Gallatin



Helena



Lolo



Lewis and Clark

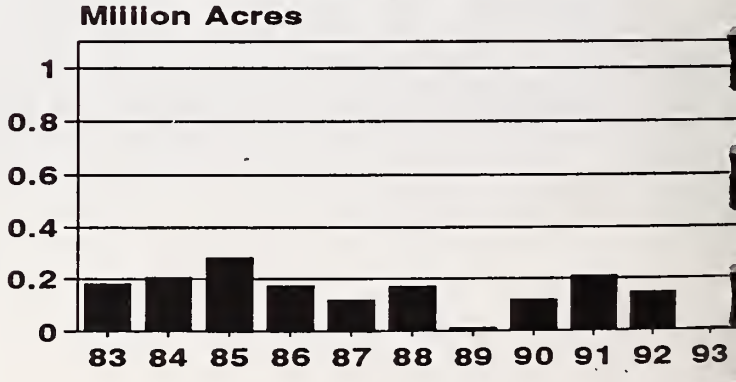


Figure 7

Western spruce budworm defoliation visible from the air in Montana and Yellowstone National Park, 1993.

1993 WESTERN SPRUCE BUDWORM SPECIAL PROJECTS

Long-Term Western spruce Budworm Impact Plots

Over the last 3 years, Forest Pest Management has installed long-term plots in historic budworm areas to assess impact and to gather data to validate/calibrate the Forest Vegetation Simulator (FVS)-linked budworm damage model. For more information on project objectives and methodology, see the 1992 Montana Conditions Report.

In 1993, new plots were established on the Deerlodge, Helena and Bitterroot NFs. Plot locations are listed below. Defoliation was rated on all previously established and new plots during the latter parts of August and September. Little current defoliation was found on any of the plots. Trap catches on plots were also very low ranging from 0 to 1 moth per stand.

During 1994, we will establish additional plots on the Beaverhead, Lewis & Clark and the Nez Perce NFs. We will also continue to validate the budworm damage model and the hazard rating system developed by Wulf and Carlson.

Western Spruce Budworm Long-Term Impact Plot Locations

National Forest	Ranger District	
Bitterroot	Stevensville	(1)
	Darby	(2)
	Sula	(1)
Beaverhead	Wise River	(2)
Clearwater	Palouse	(4)
Deerlodge	Butte	(1)
	Jefferson	(1)
Helena	Helena	(2)
	Townsend	(1)
Lewis and Clark	Kings Hill	(2)
Lolo	Missoula	(1)
	Seeley Lake	(2)
Nez Perce	Salmon River	(2)

Western Spruce Budworm Pheromone Trapping Study

During 1993, Forest Pest Management set over 507 spruce budworm pheromone traps across the Region. In addition, we also rated defoliation in all trapping areas and sampled larval populations at selected sites. Trap catches were very low at all trapping sites across the Region ranging from 0 to 1 moth caught per area. The exception was on the Lubrecht Experimental Forest and in an area just east of Canyon Ferry Reservoir on the Helena NF, where 17 and 2 moths were caught, respectively. This data will be presented in the long-term impact plot establishment report. Our preliminary analysis of the data shows a good relationship between trap catches and defoliation. Starting in 1994, Forest Pest Management will only use traps to monitor budworm population across the Region.

Evaluation Effect of Treatments on Spruce Budworm Populations and Defoliation

During 1993, Forest Pest Management evaluated the effects of various silvicultural treatments on budworm populations and associated defoliation. The results will also be included in the establishment report. We did not evaluate any new treatments in 1993. In 1994, we will evaluate additional un-even aged timber sales where budworm is currently present or has been in the past.

Gypsy Moth

Early detection efforts for the European and Asian gypsy moths continued in 1993. A total of 1,310 pheromone traps were deployed throughout the State by the USDA Forest Service, Animal and Plant Health Inspection Service (APHIS), Montana Department of Agriculture, and the Montana Department of State Lands. One male European gypsy moth was caught in an APHIS trap in Yellowstone county near Billings, Montana. APHIS is planning to intensify trapping efforts near Billings to determine if gypsy moths have become established and to define their range.

Though only one moth was caught in Montana, gypsy moth catches in adjacent states increased over past years. Two moths were trapped in Idaho near Coeur d'Alene, 10 moths were caught throughout South Dakota, and two moths were caught near Yellowstone NP in Wyoming. As the gypsy moth turns up in traps around the Region, the need for detection and delimitation grows. Thanks to those who help with the trapping detection surveys each year, proper assessment is conducted of the posed threat of this introduced insect to Montana.

Sawflies

As predicted from overwintering egg mass surveys, the sawfly infestation on the Ashland RD, Custer NF collapsed in 1993. Although ponderosa pine foliage appeared thin from the air again in 1993, larval populations were practically undetectable. It does not appear that this insect will be a problem in 1994.

Pine Tussock Moth

Pine tussock moth was again detected on the Custer NF in 1993. Larvae were abundant in early July near Poker Jim lookout on the Ashland RD and near X/X Spring in the Long Pines land unit of the Sioux RD. By August 1, the Ashland population collapsed and no defoliation was visible. On the Sioux RD, tussock moth larval populations remained high and in August late instar larvae were abundant and a number of pupae were visible. Aerial surveys detected approximately 630 acres of defoliation within the Long Pines land unit. Defoliation was moderate within the infested area.

In 1993, pine tussock moth damage was reported in Montana, Wyoming, South Dakota, and Nebraska. The simultaneous appearance of pine tussock moth across a large portion of the Great Plains is apparently unique. In order to document this phenomena, entomologists from the four States got together and conducted identical damage assessment surveys in affected areas. These surveys will be conducted each year until the population collapses. Then for a period of time thereafter, the survey will continue to assess the long-term effects of the outbreak.

Douglas-fir Tussock Moth

No adult male moths were caught in the pheromone-baited detection traps for the first time since trapping began in 1980. The tops of six ornamental blue spruce were defoliated just southwest of Polson and egg masses were also found. No visible defoliation is expected in 1994.

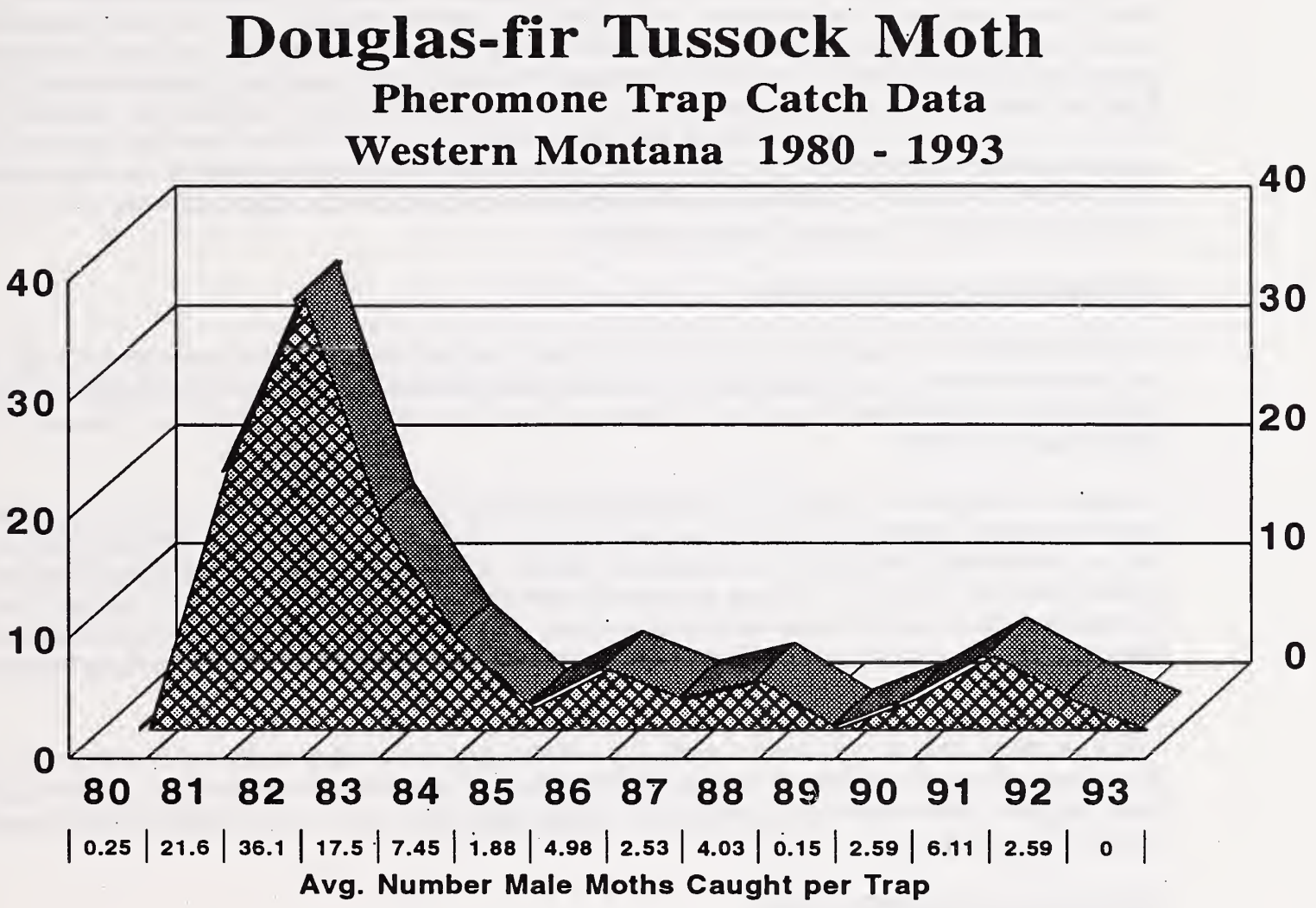

Douglas-fir Tussock Moth
Pheromone Trap Catch Data
Western Montana 1980 - 1993
40
30
20
10
0
80 81 82 83 84 85 86 87 88 89 90 91 92 93
0.25 21.6 36.1 17.5 7.45 1.88 4.98 2.53 4.03 0.15 2.59 6.11 2.59 0
Avg. Number Male Moths Caught per Trap

Figure 9

OTHER INSECTS

Tip Moths

Permanent plots were established during the summer of 1993 to try and quantify the effect of thinning on tip moth-related damage in regenerating ponderosa pine stands in southeastern Montana. Thirty plots were established in six stands along Cow Creek in the Ashland RD of the Custer NF. All six stands had been naturally regenerated after a fire; three of the stands were thinned to a 10- by 10-feet spacing during the spring of 1993. The plots will be remeasured in 2 to 5 years and more plots will be established as suitable study areas are identified.

OTHER SPECIAL PROJECTS

Ponderosa Pine Decline on the Flathead Indian Reservation

In 1992, Forest Pest Management, Northern Region and Bureau of Indian Affairs started a project on the Flathead IR to monitor the decline and mortality rate of old-growth ponderosa pine. Fifteen transect lines were established over the summer of 1993. All the ponderosa pine 15 inches or greater in diameter at breast height on each transect were tagged and located on a transect map. Data were collected on each tree, including a crown class rating which will be used to monitor the decline of each tree. This rating system is based on needle complement, needle length, needle color, and twig and branch mortality. A maximum rating of 9 is obtained when a tree rates poorly in all four areas. The ratings were then summed for each tree and categorized as 0-1 normal; 2-3 light decline; 4-5-6 moderate decline; and 7-8-9 severe decline. In all, 751 trees were tagged and given a crown rating. At this point in time, 54 percent of the trees rate out as normal, 35 percent have light decline, 9 percent have moderate decline, less than 1 percent have severe decline, and less than 1 percent are dead. We suspect that annosum root disease and several years of droughty conditions are responsible for the apparent decline. As trees die, a "postmortem biopsy" will be performed to determine the cause of mortality. With time, we should be able to determine the responsible mortality agents and also determine the rate of decline of individual trees and the overall rate of mortality.

Whitebark Pine Pilot Aerial Survey

A special aerial survey was conducted for the first time in late September on the Glacier View RD, Flathead NF, over the entire whitebark pine ecosystem. This survey was conducted to determine the feasibility of using aerial sketchmapping as an inventory tool at the landscape level for whitebark pine. This type of survey had never before been attempted.

An aerial survey specialist from Forest Pest Management and District personnel teamed up to fly approximately 100,000 acres in 9 flight hours over 2 days. The survey was flown with a Cessna 206 and three crew members; pilot, a sketchmapper/navigator and a second observer who used binoculars for a closer look and photographed different conditions. All areas above the 5,800 feet elevation band were sketchmapped into polygons representing broad condition classes of whitebark pine. Each polygon contained a code describing its condition class and the percentage of dead whitebark pine. U.S. Geological Survey, 1:24,000 topographic quadrangle maps were used for sketchmapping.

Follow-up efforts include digitizing the maps into a Geographic Information System (GIS) with code attributes and comparing old and new stand exam and ECODATA plot information in whitebark pine stands against the flight polygons. Earlier comparison results with old stand exam data seem very promising. Further comparison work will be done in 1994.

Terminal Weevil Incidence Survey

As part of an ongoing lodgepole pine terminal weevil incidence survey, 22 stands were evaluated across the Northern Region. Stands were located on the Wisdom RD, Beaverhead NF; Tally Lake RD, Flathead NF; Priest Lake RD, Idaho Panhandle NFs; Missoula RD, Lolo NF; Red River RD, Nez Perce NF; and Salmon River RD, Nez Perce NF. The stands were from 5 to 25 years old and in a variety of elevations and habitat types. Infestation level for current year's growth ranged from 0 to 31 percent. Previous years' damage was evident in all of the stands that had current year's damage. Terminal weevils kill terminals and sometimes laterals of their host trees causing stem deformities and growth loss. The survey is being conducted in both Montana and Idaho to represent a wide variety of conditions and incidence levels. The results will eventually lead to developing a hazard rating system and other management strategies, such as delaying thinning to reduce the impact of the weevil.

Whitebark Pine Cone and Seed Insect Survey

During 1993, we will begin to monitor whitebark pine forests for insects affecting the cone crop. Research has documented a rapid decline of this important species in western Montana and other areas due primarily to introduced white pine blister rust fungus and periodic outbreaks of the mountain pine beetle. There is a need to promote natural regeneration and to supplement it artificially, especially with rust-resistant nursery stock.

To date, virtually nothing is known about the role cone and seed feeding insects play on the regeneration of this species. This project will help determine the impact of cone and seed insects on seed production of whitebark pine. The project will span over a 5-year period.

DISEASES

NURSERY

Tree Improvement Diseases

New and Unusual Diseases

1. *Venturia tremulae* and *Cytospora chrysosperma* were located on cottonwood cuttings with stem and leaf blight from Bitterroot Native Growers Nursery in Hamilton.

2. Cold damage to container-grown western larch seedlings was located in greenhouses at the Montana State Nursery in Missoula. The damage was due to unusually cold temperatures while the seedlings were being stored in greenhouses after the growing season.

3. Honeysuckle blight caused by *Herpobasidium* was found on seedlings with stem blight and canker symptoms from Bitterroot Native Growers Nursery in Hamilton.

4. *Cylindrocarpon destructans* became more common on the roots of several conifer species being grown as container seedlings at the Plum Creek Nursery in Pablo. This fungus has routinely been located on roots of western white pine seedlings at the nursery, but now occurs commonly on roots of other species including Noble fir and grand fir.

Common, Recurring Diseases

1. The most common and damaging diseases of conifer seedlings in nurseries in Idaho are root diseases caused by *Fusarium* spp. These fungi cause damping-off and root diseases on many different conifer hosts in bareroot and container nurseries. These diseases are usually controlled in bareroot nurseries by soil fumigation. The most common soil-borne pathogen species in bareroot nurseries is *F. oxysporum*, although several other species are commonly isolated from infested soil and diseased seedlings. *Fusarium* diseases in container nurseries are more difficult to control and often cause greater damage than in fumigated bareroot nurseries. The major pathogen in container nurseries is *F. proliferatum*, although *F. oxysporum* and several other fusaria may also occur at high levels in some nurseries. Although all conifer species are susceptible, most damage occurs on Douglas-fir, western larch, western white pine, and Engelmann spruce.

2 *Cylindrocarpon* spp. (especially *C. destructans*) continued to cause unacceptable losses to western white pine and whitebark pine seedlings at several nurseries. Damage to other conifer species also occurs, but root decay of 5-needle pines is most serious. Control efforts to limit the amount of root decay have largely been unsuccessful.

3. *Botrytis cinerea* is a recurring problem on container western larch and Engelmann spruce seedlings. Western red cedar is also very susceptible to damage. Losses have gradually been reduced through improved cultural practices aimed at reducing inoculum and seedling susceptibility.

4. Tip dieback caused by *Sirococcus strobilinus*, *Sphaeropsis sapinea*, and *Phoma eupyrena* occurred at several nurseries on bareroot pine seedlings. Ponderosa pine and lodgepole pine were the most commonly affected species.

5. *Pythium* root disease (mostly *P. ultimum*) occurs at some level at most bareroot nurseries, but can also be found in container seedlings. Damage is usually minor and can be mitigated by improving water drainage in soil and container media.

Nursery Disease Projects

1. The U. S. Environmental Protection Agency has listed methyl bromide (a common soil fumigant used in bareroot forest nurseries throughout the United States) for phaseout by the year 2000. This chemical fumigant has been classified as depleting stratospheric ozone and will therefore be removed from production, use, and import in the United States. As a result, projects have been initiated to develop alternatives to methyl bromide in particular and chemical soil fumigants in general in forest seedling production in bareroot nurseries. Alternatives currently being tested include organic soil amendments, bare fallow periods with periodic cultivation, and different cover crops. Field plots have been established and will be monitored for effects of different treatments on seedling production and quality.

2. Investigations into the epidemiology of *Cylindrocarpon* spp. in container seedling greenhouses are continuing. Evaluations include characterizing species involved in disease, assessing pathogenicity, and formulating procedures to reduce disease losses. An evaluation to investigate fate of *Cylindrocarpon* spp. on outplanted white pine seedlings and their role on seedling performance is being conducted in cooperation with the University of Idaho and Potlatch Corporation.

3. Investigations into the pathogenic potential of *Fusarium* spp. on conifer seedlings is continuing. Techniques have been developed for rapidly screening suspected pathogenic isolates for their potential to elicit disease on young conifer germinants. These tests indicate that most isolates of *F. proliferatum* are aggressive pathogens whereas species of *F. oxysporum* vary greatly in their ability to cause disease. Pathogenic behavior information has been supplemented with recent genetic work indicating low genetic variability in isolates of *F. proliferatum*, whereas isolates of *F. oxysporum* associated with conifer seedlings exhibit a wide genetic variability (in cooperation with the University of British Columbia and B. C. Research Corporation, Vancouver, B.C.).

4. An evaluation will be forthcoming to determine efficacy of non-pathogenic *Fusarium oxysporum* to control root disease of conifer seedlings caused by pathogenic fusaria. Initial tests will be limited to laboratory and greenhouse evaluations. Depending on results of initial tests, tests at other nurseries in bareroot and container conditions may be initiated (in cooperation with the University of Idaho).

DISEASES OF GREATEST STATEWIDE IMPACT

Disease	Host	Remarks
Annosus Root Disease	Ponderosa Pine Douglas-fir Subalpine fir Other Conifers	Common in ponderosa pine stands west of the Continental Divide; especially severe on the Flathead Indian Reservation.
Armillaria Root Disease	Douglas-fir Grand Fir Other Conifers	Widely distributed, especially west of the Continental Divide. This is the most damaging root disease in western Montana. Infected trees are often attacked by bark beetles.
Laminated Root Rot	Douglas-fir Grand fir Other Conifers	Occurs throughout the range of grand fir in northwestern Montana, and is known to be particulary damaging on the Lolo and Kootenai National Forests. Infected Douglas-fir and grand fir are often attacked by bark beetles.
Dwarf Mistletoes	Lodgepole Pine Douglas-fir Western Larch	Dwarf mistletoes are widespread throughout the state and one of the leading causes of forest growth loss. Dwarf mistletoe-caused growth losses are estimated at about 33 MM ft^3/year. Lodgepole pine mistletoe occurs throughout the range of lodgepole pine. Douglas-fir mistletoe is scattered throughout the range of Douglas-fir west of a north-south line roughly 25 miles east of Missoula. Western larch dwarf mistletoe occurs throughout the range of western larch in western Montana.
White Pine Blister Rust	Western White Pine Whitebark Pine	Precludes the management of wild western white pine on all but low hazard sites throughout the range of western white pine. Rust resistant white pine has been successfully established on the Lolo, Kootenai, and Flathead National Forests. White pine blister rust occurs throughout the range of whitebark pine, causing severe mortality in localized areas and a reduction in cone production.
Pini Rot	Western Larch Pines Douglas-fir True Firs Spruce	Serious decay problem in mature conifers. May also occur at high levels in younger trees. Most important hosts are western larch and ponderosa pine.

DISEASES OF LOCAL IMPORTANCE

Stem and Branch Diseases

Aspen Canker and Trunk Rot	Aspen	Are common in most aspen stands in Monana, particularly east of the Continental Divide.
Atropellis Canker	Lodgepole Pine	Found in pockets in pole-sized stands causing defect and some mortality. Localized heavy infections are known to occur in western Montana.
Comandra Rust	Lodgepole Pine Ponderosa Pine	Causes growth loss, deformity, topkill, and mortality. Especially severe in lodgepole in south-central Montana.
Cytospora Canker	Subalpine Fir Douglas-fir Grand Fir	Occurs throughout the range of hosts. Causes branch flagging in large trees and dead tops and mortality in seedlings and saplings. Large trees may be predisposed to bark beetle attack or killed directly following drought stress.
Diplodia Blight	Ponderosa Pine	Causes stunting and mortality of new shoots. Serious infections may lead to death of the tree in association with bark beetle attack. Diplodia is scattered throughout Montana and is locally severe at several locations.
Indian Paint Fungus	Grand Fir Western Hemolock	Occurs throughout the range of hosts. This fungus is the major cause of defect in mature true fir and hemolock in western Montana.
Stalactiform Rust	Lodgepole Pine	Causes growth loss and occasional mortality. Found throughout the range of lodgepole pine and is severe in localized areas.
Western Gall Rust	Lodgepole Pine Ponderosa Pine	Causes stem and branch galls and mortality in small trees. Occurs throughout range of hosts. Infection levels are highly variable.

Root Diseases

Black Stain	Douglas-fir Lodgepole Pine Ponderosa Pine	Has been confirmed in relatively few locations in the state, all of which are west of the Continental Divide.
Brown Cubical Root and Butt Rot	Douglas-fir Other Conifers	Occurs throughout the range of hosts. Causes extensive root and butt rot; especially damaging in stands more than 80 years old.

Foliage Diseases

Elytroderma Needle	Ponderosa pine	Fungus infects the needles, twigs, and branches and causes brooming. Severe, chronic infections can cause deformation and occasional death of small trees. Known to be locally severe in the Bitterroot Valley and around Flathead Lake.
Larch Needle Blight and Needle Cast	Western Larch	Occur throughout the range of western larch. Severe infections in successive years may cause growth loss in large trees and mortality in seedlings.
Lodgepole Pine Needle Cast	Lodgepole Pine	Occurs throughout the range of lodgepole pine and is severe in localized areas. Warm, wet spring conditions are conducive for high levels of infection. Successive years of severe infections may cause growth loss in large trees and mortality in seedlings. In 1993, as in 1992, it was very visible in the far western portion of the State.
Rhabdocline Needle Cast and Swiss Needle Cast	Douglas-fir	Occur throughout the range of Douglas-fir and are quite common in northwestern Montana. Infected needles are killed and shed. Important in young plantations, including tree improvement areas and Christmas tree operations.

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APPENDIX

COMMON AND SCIENTIFIC NAMES

Diseases

Annosus root disease	*Heterobasidion annosum* (FR.) Bref.	DF, GF, PP, SAF
Armillaria root disease	*Armillaria ostoyae* (Romagn.) Herink	DF, GF, SAF
Atropellis canker	*Atropellis piniphila* (Weir) Lohn. and Cash	LPP
Brown cubical butt rot	*Phaeolus schweinitzii* (Fr.) Pat.	DF
Comandra rust	*Cronartium comandrae* Peck.	LPP, PP
Diplodia blight	*Sphaeroposis sapinea* (Fr.) Dyko.	PP
Dutch elm disease	*Ceratocystis ulmi* (Buism.)	Dutch elm
Dwarf mistletoes	*Arceuthobium* spp.	Most conifers except TF, WH, W, MH
Elytroderma needle cast	*Elytroderma deformans* (Weir) Darker	PP
Fusarium root rot	*Fusarium oxysporum* Schlect.	DF (Nursery)
Grey mold	*Botrytis cinerea* Pers. ex Fr.	WL (Nursery)
Larch needle blight	*Hypodermella laricis* Tub.	WL
Larch needle cast	*Meria laricis* Vuill.	WL
Laminated root rot	*Phellinus weirii* (Murr.) Gilb.	DF, GF, WH, SAF
Lodgepole pine needle cast	*Lophodermella concolor* (Dear.) Dark	LPP
Pini rot	*Phellinus pini* (Thore:Fr.) Pilet.	DF, WL, ES, All pines
Sirococcus tip blight	*Sirococcus strobilinus* Preuss	WWP (Nursery)
Swiss needle cast	*Phaeoeryptopus gaeumannii* (Rohde)	DF
Western gall rust	*Endocronartium harknessii* (Moore) Hirat.	LPP, PP
White pine blister rust	*Cronaritum ribicola* Fisch.	WWP, WBP

Insects

Douglas-fir beetle	*Dendroctonus pseudotsuga* Hopkins	DF
Douglas-fir tussock moth	*Orygia pseudotsugata* (McDunnough)	DF, TF, ES
Gypsy moth	*Lymantria dispar* (Linnaeus)	Most hardwoods
Mountain pine beetle	*Dendroctonus ponderosae* Hopkins	All pines
Pine engraver beetle	*Ips pini* (Say)	PP, LPP
Spruce beetle	*Dendroctonus rufipennis* (Kirby)	ES
Western balsam bark beetle	*Dryocoetes confusus* Swaine	SAF
Western spruce budworm	*Choristoneura occidentalis* Freeman	DF, TF, ES, WI
Western pine beetle	*Dendroctonus brevicomis* LeConte	PP
Fir engraver beetle	*Scolytis ventralis* LeConte	GF, SAF
Lodgepole terminal weevil	*Pissodes terminalis* Hopping	LPP
Balsam woolly adelgid	*Adelges piceae* (Ratzeburg)	SAF, GF
Pine tussock moth	*Dasychira plagiata*	PP
Sawflies	*Neodiprion autumnalis*	PP
Tip moth	*Rhyacionia species*	PP

DF = Douglas-fir; GF = Grand fir; TF = True fir; SAF = Subaline fir; PP = Ponderosa pine; LPP = Lodgepole pine; WWP = Western white pine; ES = Engelmann spruce; WH = Western hemlock; WL = Western larch; MH = Most hardwoods; WRC = Western redcedar

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